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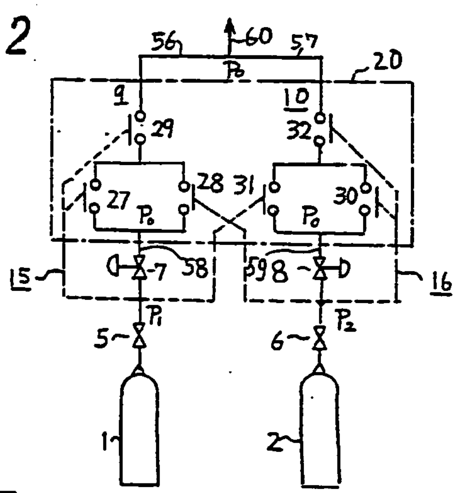
(54) Automatic gas distributing device, for supplying a pipe with gas from an alternative gas source, controlled by the direct application of high gas pressure of the source.

(57) An automatic gas distributing device for delivering gas at a constant predetermined pressure from one of a plurality of high pressure vessels (1, 2) arranged in a ring connection. The device has flow paths (9, 10) corresponding to the high pressure vessels (1, 2), and is controlled by the direct application of the pressures of the gas contained in the associate vessels (1, 2) to the relevant stop valves (27-32). The device automatically set a high pressure vessel having a lower gas pressure than other vessels in operation, and interrupts the high pressure vessel in operation when the gas pressure of the vessel is reduced below a control pressure, and actuate the succeeding vessel.

FIG. 2



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AUTOMATIC GAS DISTRIBUTING DEVICE, FOR SUPPLYING A PIPE WITH GAS FROM AN ALTERNATIVE GAS SOURCE, CONTROLLED BY THE DIRECT APPLICATION OF HIGH GAS PRESSURE OF THE SOURCE

BACKGROUND OF THE INVENTION

The present invention relates to an automatic gas distributing device employed in a gas supplying system having a gas source under a high pressure stored in a plurality of high pressure vessels. Particularly, the present invention relates to an automatic gas distributing device, being capable of automatically exchanging a flow path from a high pressure vessel in operation for that from another high pressure vessel on standby with full gas pressure without dropping the supplying gas pressure during the exchanging period.

In a fabrication process of a semiconductor device, such as a chemical vaporizing deposition (CVD), various gases, such as silane (SiH_4), hydrogen (H_2) etc., are used. Generally, these gases are supplied to a fabricating apparatus under a predetermined gas pressure which is strictly required to be maintained within a small allowable variation range in order to perform the relevant fabrication process in a stable and reliable state. Accordingly, during an exchanging interval when a drained high pressure vessel with a reduced gas pressure below a specified control pressure is exchanged for a new one on stand-by, storing the gas with a full pressure, it is essentially important to maintain the supplying gas pressure constant, and no pressure drop of the supplying gas is allowed through all the exchanging interval.

A prior art gas supplying system is described referring to a schematic diagram of Fig.1. The system contains a gas distributing device for supplying gas continuously from two high pressure vessels 1 and 2 alternatively to a utilization pipe to be connected to a fabricating apparatus. The high pressure vessel, 1 or 2, is connected to, or disconnected from the system using a connecting valve 3 or 4, respectively. During the exchanging interval, shut-off valves 5 and 6 are closed. The pressure of the gas (hereinafter, primary pressure) of the high pressure vessel 1 or 2, is regulated by a regulator 7 or 8, to a low pressure (hereinafter secondary pressure), namely utilization pressure of the gas. The regulated gas is sent to a utilization pipe (not shown), through a directional control valve 19 which is operated automatically or manually. Gas pressure indicators 11 and 12, are disposed upstream the gas regulators 7 and 8, respectively for indicating the respective primary pressure. Downstream the regulators 7 and 8, another indicators 13 and 14, are disposed for indicating the secondary pressure. In a manual operation of the device, the primary pressure of the high pressure vessels 1 or 2, are read by an operator and one of the vessels 1 and 2 is selected by operating the directional control valve 19 upon assuring that the secondary pressure of the relevant vessels reaches the specified utilization gas pressure. In an automatic operation, the pressure indicators 11 and 12 are replaced by pressure signal generators, and the directional control valve 19 is replaced by an electrically or pneumatically driven directional control valve which operates in accordance with signals issued by the pressure signal generators. Thus, the drained high pressure vessel having a primary pressure below a predetermined control pressure is replaced by a full high pressure vessel. Consequently, the gas under the utilization gas pressure is supplied to the utilization pipe without any break and pressure drop. However, in the above-described automatic control system, an electrical and pneumatic power source are further reqired, making the system more complicated and expensive. In particular, when these power sources are out of order, the operation of the whole gas supplying system is stopped, causing a substantial damage to the fabricating process.

The above-described prior art gas distributing device has been occasionally accompanied with some miss-operation and high labor cost of the relevant operators. In order to overcome these disadvantages, various improved automatic gas distributing devices have been proposed. Most of them are of the type where the change of the secondary pressure of the gas is detected by deformation of a diaphragm member, and the deformation is converted into an electrical control signal which is sent to the relevant control valves. However, the change of the secondary pressure is very small, particularly, when the change of the secondary pressure is required to be strictly controlled as in the semiconductor fabrication apparatus. As a result, the control signal becomes very delicate, depressing the accuracy of the control operation. Furthermore, if the relevant gas is corrosive, or explosive, the employment of electrical components are rather undesirable in view of the safety and the reliability of the gas supplying system.

Meanwhile, there is proposed an automatic gas distributing device where primary pressure of the gas source is utilized as a power source of the device. The device is an automtic gas delivery device disclosed by Gerard Loiseau et al. in U.S. Patent No.4,597,406 published on July 1, 1986. Usually, the change of the primary pressure of the

high pressure vessels is large and advantageous to provide sensitive control signals for controlling the gas delivery device. In the automatic gas delivery device of Loiseau et al., various conventional pneumatic elements are utilized for detecting the primary pressure of the two high pressure vessels, one of which is in operation and the other is on stand-by. Gas flow coming from the high pressure vessel which is drained below a predetermined pressure, is automatically exchanged for that from a full high pressure vessel on stand-by. The whole control system is driven by the aid of pneumatic controlling elements. Although there are advantages inherent to the device, such as absence of an electrical power source, the use of a number of pneumatic elements are considered to make the device complicated and expensive.

SUMMARY OF THE INVENTION

An object of the present invention, is to provide an automatic gas distributing device for automatically controlling the delivery of low pressure gas coming from one of a high pressure vessels, in order to send the gas to a utilization pipe.

Another object of the present invention is to provide ar automatic gas distributing device for delivering gas remaining under a precisely assured pressure to a utilization pipe, even during the time of switching-over from a drained high pressure vessel to a full high pressure vessel on stand-by.

Still another object of the present invention is to provide an automatic gas distributing device being operable in accordance with the primary pressure of the relevant high pressure vessels without the aid of another external power source, thus having a simple and non-expensive structure.

Fig.2 is a schematic diagram illustrating a gas supply flow paths of the first embodiment of the present invention, in which two high pressure vessels are used. The high pressure vessels 1 and 2, having primary pressures P_1 and P_2 respectively, are connected or disconnected to the relevant gas supplying apparatus using valves 3 and 4 respectively. The primary gas pressures P_1 and P_2 are regulated by regulators 7 and 8 to a utilization pressure, namely a secondary pressure, P_0. The gas under the pressure P_0, namely the low pressure gas, is supplied through a supply pipe 58 or 59 to a automatic gas distributing device 20. The low pressure gas under the gas pressure P_0 is alternatively supplied from one of the high pressure vessels 1 and 2 under the control of the automatic gas distributing device 20. The gas is then supplied through a commonly used utilization pipe 60 to a fabrication apparatus needing the gas, such as a CVD apparatus.

As shown in Fig.2, the automatic gas distributing device 20 has two flow paths 9 and 10 disposed in parallel, corresponding to the high pressure vessels 1 and 2. Each flow path includes a parallel flow path and a flow path connected to the parallel path in series. In the flow path 9 corresponding to the high pressure vessel 1, for example, the parallel flow path comprises two branch paths respectively including a stop valve 27 operable by the pressure difference between the primary pressures P_1 and P_2, and another stop valve 28 operable in accordance with the primary pressure P_2 of the another high pressure vessel 2. In series with the above-described parallel flow path, a flow path is connected including a stop valve 29 operable in accordance with the primary pressure P_1 of the high pressure vessel 1. In another point of view, the flow path 9 comprises a flow path including the stop valve 28 and stop valve 29 connected in series, and a flow path including the stop valve 27, by-passing the stop valve 28.

These stop valves may be conventional seat valves, each comprising a valve seat, a valve plunger, a coil spring, a piston connected to the end of the plunger, as shown in Fig.3. Conventional pilot valves are also applicable instead of the seat valves. When the pressures P_1 is higher than a predetermined control pressure P_c, the stop valve 29 is opened and the stop valve 31 is closed, and vice versa when the pressures P_1 is below the control pressure P_c. In accordance with the pressure P_2, the stop valves 32 and 28 operate in the similar manner. The control pressure P_c is determined to be a pressure in the proximity of the utilization pressure P_0. The stop valves 27 and 30 are connected mechanically to each other, and cooperate with each other. When, the pressure P_1 is lower than the pressure P_2, then the stop valve 27 is opened, and the stop valve 30 is closed, and vice versa when P_1 is higher than P_2. Thus, if one pressure gas vessel in operation is drained, then the other vessel on stand-by operates automatically, and if both vessels have high primary pressures, then the vessel having a lower primary pressure is selectively operated, and the other vessel remains on stand-by.

The dot lines in Fig.2 indicates the relevant actuating paths 15 and 16 for propagating the primary pressures P_1 and P_2 to the associated stop valves to drive the stop valves. As described above, all the stop valves are driven by the primary pressures of the high pressure vessels P_1 and P_2 propagated through the actuating paths 15 and 16.

Furthermore, the principle of the above-described structural configuration and the operation, is extended to an automatic gas distributing device for a gas supplying system including high pressure vessels of a number larger than two.

The details of an automatic gas distributing device according to the present invention, will be more apparent by the read of the description of embodiments and claims, referring to accompanying drawings wherein like reference numerals designate like parts.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a schematic diagram, illustrating a prior art gas supplying system;

Fig.2 is a schematic diagram illustrating gas supply flow paths of the first embodiment of the the present invention;

Fig.3 is a schematic cross-sectional view of a first embodiment of the present invention, illustrating the structural configuration of an automatic gas distributing device;

Fig.4 is a diagram illustrating a gas flow of the automatic gas distributing device which is in the state shown in Fig.3;

Fig.5 is a time diagram, illustrating the change of the primary pressures P_1 and P_2 with time with respect to the first embodiment;

Fig.6 is a schematic cross-sectional view of the first embodiment of the present invention, illustrating the state thereof at time t_2 shown in the time diagram of Fig.5;

Fig.7 is a diagram illustrating a gas flow of the automatic gas distributing device which is in the state shown in Fig.6;

Fig.8 is a schematic cross-sectional view of the first embodiment of the present invention, illustrating the state thereof at time t_3 shown in the time diagram of Fig.5;

Fig.9 is a diagram illustrating a gas flow of the automatic gas distributing device which is in the state shown in Fig.8;

Fig.10 is a schematic cross-sectional view of the first embodiment of the present invention, illustrating the state thereof at time t_4 shown in the time diagram of Fig.5;

Fig.11 is a diagram illustrating a gas flow of the automatic gas distributing device which is in the state shown in Fig.10;

Fig.12 is a plan view of an actual example of the first embodiment, illustrating the arrangement of the pneumatic components and connecting pipes;

Fig.13 is a cross-sectional view of the first embodiment shown in Fig.12 taken along the chain line A-A of Fig.12, illustrating the actual structure of the first embodiment; and

Fig.14 is a diagram illustrating a gas flow of the automatic gas distributing device of the second embodiment of a supplying system including five high pressure vessels.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig.3 is a schematic cross-sectional view of a first embodiment of the present invention, illustrating the structural configuration of an automatic gas distributing device 20.

As shown in Fig.3, the gas coming from the high pressure vessel 1 is supplied to the automatic gas distributing device 20 through inlet ports 21 and 22, and is issued into a supplying pipe 56 through a path 69 and an outlet port 23. Similarly, the gas coming from the high pressure vessel 2 is supplied to the automatic gas distributing device 20 through inlet ports 24 and 25, and is issued into a supplying pipe 57 through a path 70 and an outlet port 26. Stop valves 29 and 31 are driven by primary pressures P_1, stop valves 32 and 28 by primary pressure P_2, and stop valves 27 and 30 by the difference between the primary pressures P_1 and P_2. The primary pressures P_1 and P_2 are applied to the above stop valves through actuating paths 15 or 16 (reference numerals thereof are not shown), and open or close the inlet or outlet ports, 21, 22, 23, 24, 25, and 26.

Fig.4 is a diagram illustrating a gas flow of the automatic gas distributing device which is in the state shown in Fig.3. The stop valves are represented in the analogy of an electrical switching circuit using electrical switches, wherein an ON switch corresponds to a closed stop valve, and an OFF switch corresponds to a closed stop valve. The flow path 9 comprises inlet ports 21 and 22, outlet port 29, connecting flow paths 69 disposed between the stop valves 27, 28 and 29. By controlling the stop valves, the flow paths including stop valves 28 and 29 can be connected in series and the stop valve 28 can be by-passed by a passage including the inlet port 21, the stop valve 27, the flow path 69, and the outlet port 23. Another flow path 10 has also a similar configuration to the flow path 9: flow paths including the stop valve 31 and stop valve 32 are connected in series, and the stop valve 31 is by-passed by another path including the inlet port 24, the stop valve 30, the path 70, and the outlet port 26. The flow path 9 is opened and flows the gas coming from the high pressure valve 1 when the two stop valves 29 and 27, or the two stop valves 29 and 28, are opened at the same time. The flow path 10 is opened or closed in the similar way.

These stop valves described are conventional seat valves. Each valve comprises a valve seat, a valve plunger, a piston connectd to the valve plunger, a cylinder hall slidably accepting the piston, and a coil spring energizing the plunger in a direction to close or open the valve depending on its use. In practice, the piston is often replaced by

a diaphragm. The displacement of the valve plunger in the axial direction is provided by the deformation of the diaphragm caused by a pressure of applied gas pressure to the valve.

Of course, these seat valves can be replaced by plunger valves or pilot valves. The stop valves 28 and 31 are energized by each own coil spring disposed with respect to each valve plunger such that the stop valves 28 and 31 are closed when the exposed gas pressure P_1 or P_2 is higher than a predetermined control pressure P_c , and vice versa when the pressure P_1 or P_2 is below the control pressure P_c. On the contrary, the stop valves 29 and 32 are energized such that the stop valves 29 and 32 are opened when the exposed gas pressure higher than a predetermined control pressure P_c, and vice versa when the pressure P_1 or P_2 is below the control pressure P_c.

The stop valves 27 and 28 are mechanically connected by a connecting rod 35 at the middle point of which a piston disk 34 is disposed separating a cylinder 33 into cylinder halls 33a and 33b. The primary pressure P_1 is supplied into the cylinder hall 33a and P_2 into the cylinder hall 33b. Consequently, the piston 34 is moved toward the stop valve 27 or 30 depending on the pressure difference between both primary pressures P_1 and P_2.

In order to actuate the associated stop valves, the automatic gas distributing device has actuating paths 15 and 16 corresponding to the flow paths 9 and 10. The actuating path 15 comprises an inlet port 37, a cylinder hall 33a, a port 40, a cylinder hall 41, a port 42 and a cylinder hall 43. The actuating path 16 also comprises an inlet port 39, a cylinder hall 33b, a port 48, a cylinder hall 49, a port 50 and a cylinder hall 51.

In a special case where the primary pressures P_1 and P_2 are almost equal, in a state at time t_0 as shown in Fig.5, providing almost no pressure difference to the piston 34, the performance of the stop valves 27 and 30 becomes unstable, failing to decide the priority of the operation of the high pressure vessels 1 or 2. This case occurs when a gas supplying system runs in operation for the first time with newly installed two full high pressure vessels. Only one of the two stop valves, the stop valve 5, for example, whose relevant vessel 1 is to be in operation first, is opened, and after an appropriate time when P_1 is fairly lower than P_2, then the stop valve may be closed. That is, the problem may be overcome manually, and is performed at the installation of the two full high pressure vessels 1 and 2 into the gas supplying system.

In summary, when the primary pressure P_1 is lower than P_2, the stop valve 27 is opened and the stop valve 30 is closed. When P_1 is higher than P_2, the stop valve 27 is closed and the stop valve 30 is opened. When P_1 is higher than P_c, the stop valve 29 is opened, and the stop valve 31 is closed. When P_1 is lower than P_c , the stop valve 29 is closed and the stop valve 31 is opened. When P_2 is higher than P_c, the stop valve 32 is opened and the stop valve 28 is closed. When P_2 is lower than P_c, the stop valve 32 is closed and the stop valve 28 is opened.

With this configuration, the operation of the automatic gas distributing device 20 will be described referring to Fig.5, a time diagram, illustrating the change of the primary pressures P_1 and P_2 with time. It is assumed that, at time t_1, the primary pressure P_1 is lower than P_2, and higher than the control pressure P_c at time t_1. Fig.3 illustrates this state, namely, $P_1 = 50 Kg/cm^2$, $P_2 = 100\ Kg/cm^2$, and $P_c = 5\ Kg/cm\beta$. As is seen from Fig.3 and Fig.4, the stop valves 29 and 32 are opened and the stop valves 28 and 31 are closed because both primary pressures P_1 and P_2 are higher than P_c. However, the stop valve 27 is opened and the stop valve 30 is closed, opening the flow path 9. The gas flows as indicated by dotted lines, and is supplied to the utilization pipe 60 from the high pressure vessel 1.

Then, the primary pressure P_1 reduces with time, draining the high pressure vessel 1, and at a time t_2, P_1 becomes lower than P_c, resulting in closing the stop valve 29 and opening the stop valve 31 as shown in Fig.6 and Fig.7. Because the primary pressure P_1 is still lower than P_2, and P_2 is higher than P_c, the state of the other stop valves remains unchanged. Accordingly, the flow path 9 is closed by the closed stop valve 29, and, at the same time, the flow path 10 is opened by the opened stop valve 31 which by-passes the closed stop valve 30. The gas now flows through the flow path 10 as represented by a dotted line in Fig.7. The supply of the low pressure gas to the utilization pipe 60 is thus maintained without any breakdown. After the switching-over from the high pressure vessel 1 to the high pressure vessel 2, at time t_3, the drained high pressure vessel 1 is replaced by a full high pressure vessel. The primary pressure P_1 goes up again up to a high pressure such as $100\ Kg/cm^2$.

Fig.8 illustrates the state of the device 20, and Fig.9 is a corresponding diagram illustrating the passage of the gas at time t_3. Because the primary pressures P_1 and P_2 are higher than P_c, the stop valves 29 and 32, are opened, and the stop valves 28 and 31 are closed. However, the primary pressure P_1 is higher than the primary pressure P_2, the stop valve 30 is opened and the stop valve 27 is closed, resulting in opening the flow path 10 and closing the flow path 9, and the gas flows as indicated by a dotted line. Hereby, the closed stop valve 31 of the flow path 10 is by-passed by the stop valve 30. Then, the gas stored in the high

pressure vessel 2 is gradually consumed with time, and the primary pressure P_2 of the high pressure vessel 2 is reduced, becoming lower than the control pressure P_c at time t_4.

As shown in Fig.10, the reduction of the primary pressure P_2 below the P_c, makes the stop valve 32 close and the stop valve 28 open. The other stop valves remains unchanged because P_1 is still higher than P_2 and P_1 is still at high pressure, higher than P_c. Consequently, the flow path 9 is opened and the flow path 10 is closed at the same time. The gas is now supplied from the high pressure vessel 1 again through the flow path 9 as represented by a dotted lines in Fig.11. The high pressure vessel 2 is in a drained state to be displaced with another fresh high pressure vessel.

Fig.12 is a plan view of an actual example of the first embodiment, and Fig.13 is a cross-sectional view of the same, taken along the chain line A-A of Fig.12. Reference numerals represents the corresponding parts shown in the preceding drawings. The connection between pneumatic parts are performed generally by using stainless pipes. The stop valves are seat valves which may be displaced by stop valves of other types. The pistons shown in the preceding drawings such as Fig.Fig.3, are replaced by diaphragms whose cross-sections are represented by straight lines in Fig.13, and each piston plunger is supported by a pair of 'O rings' 71. The relevant pneumatic parts are conventional ones available in the market, and no further description regarding Fig.12 and Fig.13 may be unnecessary to those skilled in the art.

As described in detail, the alternative supply of the gas to the utilization pipe 60 is continued automatically by the automatic gas distributing device 20 of the present invention. All the stop valves are driven utilizing the primary pressures P_1 and P_2 propagated through the actuating paths 15 and 16, requiring no additional electrical or pneumatic power source and relevant components to set up a controlling system for controlling the stop valves. As the result, the structure of the automatic gas distributing device according to the present invention, the first embodiment, is substantially simplified, assuring a reliable gas supplying operation and a low cost of the device.

The first embodiment contains only two high pressure vessels which are alternatively used. If the capacity of each high pressure vessel is small, then replacement of the drained high presure vessel with a new full high pressure vessel will be required frequently. In such a case, a number of high pressure vessels are desired to be installed on stand-by for replacing several drained high pressure vessels at a time. The principle of the first embodiment having two high pressure vessels is now extended to a case wherein more than two high pressure vessels are prepared for stand-by. Basically, the high pressure vessels are connected in a ring connection, and successively and alternatively operated in a direction such as a anti-clockwise direction. The pneumatic parts, high pressure vessels, connecting means, etc, of the secong embodiment, are quite similar to those of the first embodiment. The description of the second embodiment, therefore, will be provided referring to flow path diagram of Fig.14 only, and that of structural configuration is omitted.

The gas supplying apparatus having an automatic gas distributing device 1000 of the second embodiment, includes five high pressure vessels, 101, 201, 301, 401, and 501 having primary pressures P_1, P_2, P_3, P_4, and P_5 respectively as shown in Fig.14. The gas under a utilization pressure P_0, is alternatively delivered from one of the high pressure vessels and supplied to a common utilization pipe 100. The automatic gas distributing device 1000 has flow paths 110, 210, 310, 410, and 510 corresponding to the high pressure vessels 101 to 501. For example, the flow path 110 is interposed by a first stop valve 105, a second stop valve 106, a third stop valve 107, and a fourth stop valve 108. As shown in Fig.14, and in the similar manner to he first embodiment, the stop valves 106, 107, and 108 are disposed in parallel, and the stop valve 105 is disposed in series with the stop valves disposed in parallel. The first stop valve 105 is opened when the primary pressure P_1 is higher than a control pressure P_c, and closed when lower than P_c, closing the flow path 101. The second stop valve 106 is opened when the preceding primary pressure P_5 of the preceding high pressure vessel 501 is lower than P_c, and closed when higher than P_c. The fourth stop valve 108 is opened when the next primary pressure P_2 of the high pressure vessel 201 is higher than P_1. The third stop valve 107 is opened when the preceding primary pressure P_5 is higher than the primary pressure P_1.

For example, when the primary pressure P_1 of the high pressure vessel 101 in operation is reduced below the control pressure P_c and the high pressure vessel 101 is drained off, the first stop valve 105 is closed, cutting off the associated flow path 110, and the second stop valve 206 of the next flow path 210 is opened. The first stop valve 205 of the flow path 210 has been already opened because the high pressure vessel 201 on stand-by has a high primary pressure P_2. Thus, the next flow path 210 is opened at the same time, putting the next high pressure vessel 201 in operation. In this manner, when the high pressure vessel in operation is drained and the primary pressure thereof is reduced below the control pressure P_c, then the flow path of the drained high pressure vessel is closed and the flow path for the next high pressure

vessel on stand-by is opened. Thus the exchange of a drained high pressure vessel for the next high pressure vessel on stand-by is preformed automatically. Since the high pressure vessels are connected in ring connection, enabling the exchange to be continued successively as long as the drained high pressure vessels are replaced with full high pressure vessels in an appropriate time. This means that two or more drained high pressure vessels are allowed to be replaced at a time, not at time of each replacement for full high pressure vessels, for a period, providing a operational convenience to the relevant operator.

During the operation of the gas supplying system, the drained high pressure vessel immediately preceding the high pressure vessel in operation may be replaced with a full high pressure vessel. With the automatic gas distributing device having the above-described configuration, the high pressure vessel in operation is cut off, because the second stop valve is closed by the high primary pressure of the preceding high pressure vessel newly replaced. In order to avoid this problem, further valve control means including a third stop valve and a fourth stop valve is added to each of the above-described flow path as shown in Fig.14. For, example, in a flow path 109, a third stop valve 107 and a fourth stop valve 108 are disposed in flow paths in parallel with the flow path including a second stop valve 106. With the similar configuration to the stop valves 27 and 30 of the first embodiment, the third stop valve 107 of the flow path 109 is cooperated with a fourth stop valve 508 of the preceding flow path 509 and are driven in accordance with the pressure difference between the relevant adjacent two high pressure vessels 101 and 501. Both stop valves 107 and 508 are mechanically connected as described before. Other third stop valves and fourth stop valves are disposed in the same manner. The fourth stop valve 108 and the third stop valve 207 of the next flow path 209 cooperate with each other. Since the primary pressures P_5 and P_2 are higher than P_1, in the above case, both third and fourth stop valves 107 and 108 are closed. Although the second stop valve 106 is closed by the newly replaced high pressure vessel 501, the opened first stop valve 105, third stop valve 106 and fourth stop valve 108 makes the flow path 109 open, resulting in the high pressure vessel 101 in operation. In comparison with the first embodiment, the first stop valves, the second stop valves, and both of third and fourth stop valves of the second embodiment, correspond to stop valve the stop valve 29, the stop valve 28 and the stop valve 27 of the first embodiment.

Because of the ring connection of the high pressure vessels, in the second embodiment, the fourth stop valves are necessary in addition to the third stop valves in each flow paths.

The replacement of the drained high pressure vessels is desirable to be performed from the earlier stage in order to avoid making plural high pressure vessels in operation. Assuming that a high pressure vessel 301 is in operation, and high pressure vessels 101 and 201 are drained, for example, if the high pressure vessel 201 is replaced first, remaining the high pressure vessel 101 drained, then the second stop valve 206 is also opened making the high pressure vessel 201 in operation. Thus two high pressure vessels 202 and 301 are in operation, which is not desirable for steady maintenance of the gas supplying system.

The second embodiment is described with the case of five high pressure vessels installed in the relevant gas supplying system, however it is apparent that the technology is applicable to the systems including three, four or more than five high pressure vessels.

Although there have been described what are at present considered to be the preferred embodiments of the present invention, it will be understood that the invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all aspects as illustrative, and restrictive. The scope of the invention is indicated by the appended claims rather than by the foregoing description.

Claims

1. An automatic gas distributing device installed in a gas supplying system for supplying a utilization pipe (60) with gas at a low predetermined secondary pressure, the gas coming from either of two high pressure vessels (1, 2) initially containing said gas under a high primary pressure which is regulated into said secondary pressure,
said device being characterized by
two flow paths disposed corresponding to said high pressure vessels (1, 2) each flow path containing a plurality of stop valves (27-32) actuatable by the application of said primary pressure of the gas contained in said high pressure vessels (1, 2), receiving said gas under said secondary pressure coming from the associated high pressure vessel (1, 2), and issuing said gas under the secondary pressure into said utilization pipe (60); and
two actuating means (15, 16) disposed corresponding to said high pressure vessels (1, 2), for selectively applying the primary pressures of the gas contained in the corresponding high pressure ves-

sel (1, 2) to said stop valves (27-32) contained in said flow paths to actuate said stop valves (27-32), said stop valves contained in each of said flow paths comprising:

a first stop valve (29, 32) being operable in accordance with the primary pressure of the gas contained in the corresponding high pressure vessel (1, 2);

a second stop valve being disposed in series with said first stop valve (28, 31), and being operable in accordance with the primary pressure of the gas contained in the other high pressure vessel (2, 1); and

a third-valve (27, 30) disposed in a flow pass which by-passes said second stop valve (28, 31), being operable in accordance with the difference between the pressures of the gas contained in both high pressure vessels (1, 2).

2. An automatic gas distributing device (20) installed in a gas supplying system for supplying a utilization pipe (60) with low pressure gas at a predetermined utilizing pressure P_0, the gas coming from either of first high pressure vessel (1) under a primary pressure P_1 and a second high pressure vessel (2) under a primary pressure P_2, initially containing said gas under a high primary pressure which is regulated to a secondary pressure as low as P_0 by respective pressure regulator (7, 8),

said device (20) being characterized

a first flow path (9) for passing said gas under said secondary pressure coming from said first high pressure vessel (1), having a first stop valve (29), second stop valve (28) which is connected in series with said first stop valve (29) and a third stop valve (27) disposed in a flow path by-passing said second stop valve (28);

a second flow path (10) for passing said gas under said secondary pressure coming from said second high pressure vessel (2), having a first stop valve (32), second stop valve (31) which is connected in series with said first stop valve (32), and a third stop valve (30) disposed in a flow path by-passing said second stop valve (31);

an actuating means (15) disposed corresponding to said high pressure vessel (1), for applying the primary pressure P_1 of the gas contained in said high pressure vessel (1) to stop valves (27, 29, 31) to control said stop valves (27, 29, 31); and

an actuating means (16) disposed corresponding to said high pressure vessel (2), for applying primary pressures P_2 of the gas contained in said high pressure vessels (2) to stop valves (28, 30, 32) to control said stop valves (28, 30, 32), thereby

said first stop valve (29) of said first flow path (9) and said second stop valve (31) of said second flow path (10) are operated in accordance with said primary pressure P_1 of the gas contained in said first high pressure vessel (1) and a predetermined control pressure P_c,

said first stop valve (32) of said second flow path (10) and said second stop valve (28) of said first flow path (9) are operated in accordance with said primary pressure P_2 of the gas contained in said second high pressure vessel (2) and said control pressure P_c, and

said third stop valves (27, 30) are operated cooperatively in accordance with the difference between said primary pressures P_1 and P_2.

3. An automatic gas distributing device of claim 1 or 2, characterized in that said first stop valve (29, 32) comprises a valve seat, a valve plunger, a piston (44, 52) connected to the valve plunger, a cylinder hall (41, 49) slidably accepting the piston (44, 52), and a coil spring (46, 54), said coil spring (46, 54) energizing the plunger in a direction toward the valve seat with a spring force corresponding to said control pressure P_c.

4. An automatic gas distributing device of any one of claims 1 to 3, characterized in that said second stop valve (28, 31) comprises a valve seat, a valve plunger, a piston (53, 45) connected to the valve plunger, a cylinder hall (51, 43) slidably accepting the piston (53, 45), and a coil spring (55, 47), said coil spring (55, 47) energizing the plunger in an opposite direction toward the valve seat with a spring force corresponding to said control pressure P_c.

5. An automatic gas distributing device of any one of claims 1 to 4, characterized in that said third stop valves (27, 30) are disposed in the form of a sliding differential switching valve comprising two plunger heads, a rod (35) mechanically connecting both plunger heads, a piston (34) disposed on a portion of said rod (35) locating between said plunger heads, and a hall (33) accepting said piston (34) slidably.

6. An automatic gas distributing device of any one of claims 2 to 5, characterized in that said first valve (29) of said first flow path (9) is opened, and said second stop valve (31) of said second flow path (10) is closed, when said primary pressure P_1 of the gas contained in said first high pressure vessel (1) is higher than a control pressure P_c, and said stop valves (29, 31) operate in the opposite state to those described above when said primary pressure P_1 is lower than said control pressure P_c.

7. An automatic gas distributing device of any one of claims 2 to 6, characterized in that said first valve (32) of said second flow path (10) is opened, and said second stop valve (28) of said first flow path (9) is closed, when said primary pressure P_2 of the gas contained in said second high pressure vessel (2) is higher than a control pressure P_c, and

said stop valves (32, 28) operate in the oppsite state to those described above when said gas pressure P_2 is lower than said control pressure P_c.

8. An automatic gas distributing device of any one of claims 2 to 7, characterized in that said control pressure P_c is set at a pressure close to said utilization pressure P_0.

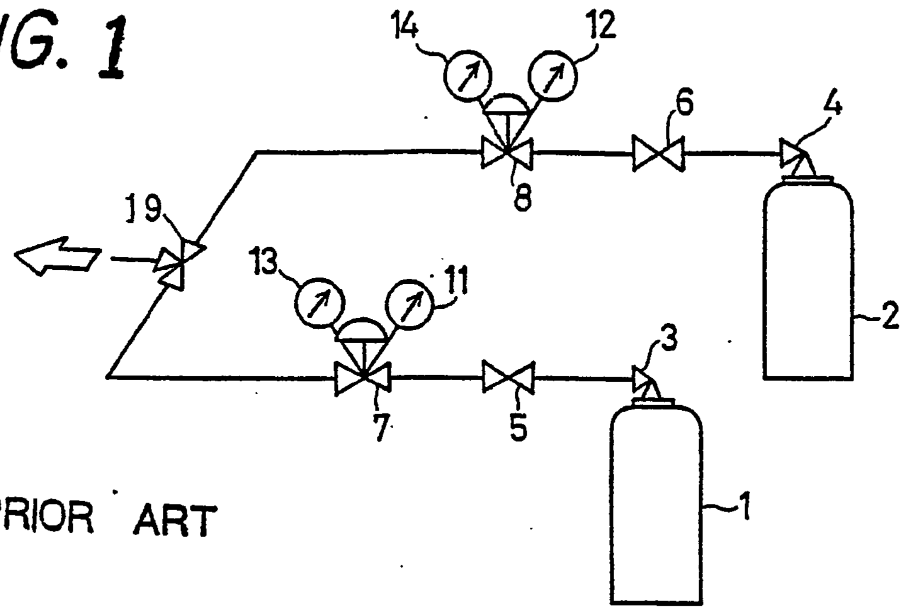
9. An automatic gas distributing device of any one of claims 2 to 8, characterized in that said third valve (27) of said first flow path (9) is opened and said third stop valve (30) of said second flow path (10) is closed simultaneously, when the primary pressure P_1 is lower than the primary pressure P_2, and said third stop valves (27,30) are operated in the opposite state to those described above, when the primary pressure P_1 is higher than the primary pressure P_2.

10. An automatic gas distributing device of any one of claims 2 to 9, characterized in that said first flow path (9) is established and said flow path (10) is interrupted when the primary pressure P_1 is higher than said control pressure P_c and lower than the primary pressure P_2, and vice versa.

11. An automatic gas distributing device of any one of claims 4 to 10, characterized in that said pistons are diaphragms.

12. An automatic gas distributing device installed in a gas supplying system for applying a utilization pipe (1000) with gas at a predetermined low secondary pressure, the gas coming from one of a plurality of high pressure vessels (101, 201 ...) arranged in a circulating connection, initially being contained in said high pressure vessels (101, 201 ...) under a high primary pressure, and being regulated into said secondary pressure gas by the associated gas regulators,
said device being characterized by
a plurality of flow paths (109, 209...) disposed corres ponding to said high pressure vessels (101, 201, 301, 401), each flow path containing a plurality of stop valves (105-109, 205-209...) actuatable by the application of said primary pressures of the gas of said high pressure vessels (101, 201, ...) receiving said gas under said secondary pressure supplied from the corresponding high pressure gas vessel (101, 201, ...) and issuing said gas into said utilization pipe (1000); and
a plurality of actuating means disposed corresponding to said high pressure vessels (101, 201, ...), for alternatively applying said primary pressures of the gas contained in the associated high pressure vessels (101, 201, ...) to said stop valves (105-109, 205-209, ...) contained in said flow paths (109, 209, ...) to actuate said stop valves (105-109, 205-209, ...), said stop valves contained in each of said flow paths being:
a first stop valve (105, 205, ...) being operable in accordance with the primary pressure of the gas contained in the associated high pressure vessel (101, 201, ...);
a second stop valve (106, 206, ...) being disposed in series with said first stop valve (105, 205, ...), and being operable in accordance with the primary pressure of the gas contained in the high pressure vessel (501, 101, ...) of the preceding stage;
a third valve (107, 207) disposed in a flow path which by-passes said second stop valve (106, 206), being operable in accordance with the difference between the primary pressures of the gas contained in the associated high pressure vessel (101, 201, ...) and the high pressure vessel of the preceding stage (501, 101, ...); and
a fourth valve (108, 208, ...) disposed in a flow path which by-passes said second stop valve (106, 206, ...) being operable in accordance with the difference between the primary pressures of the gas contained in the associated high pressure vessel (101, 201) and the high pressure vessel of the next stage (201, 301, ...).

FIG. 1



PRIOR ART

FIG. 2

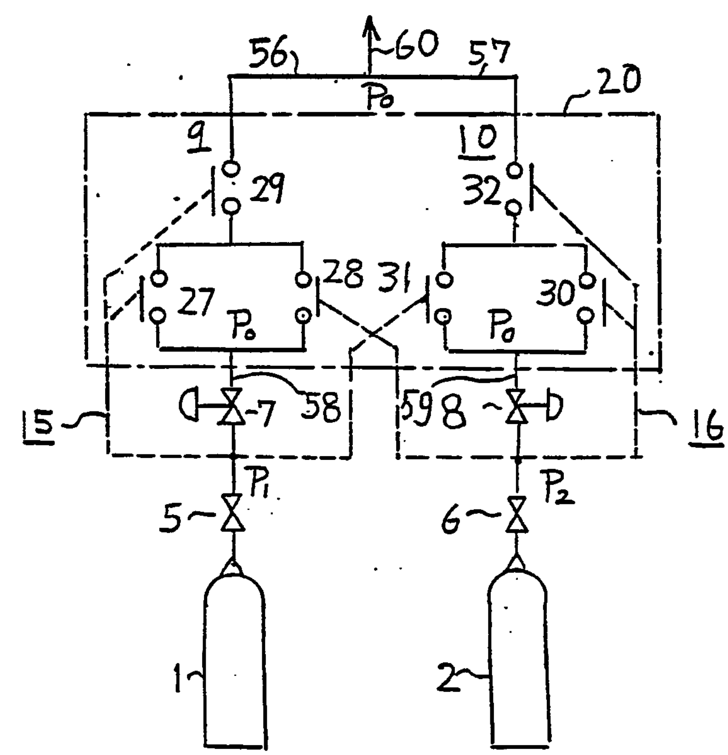
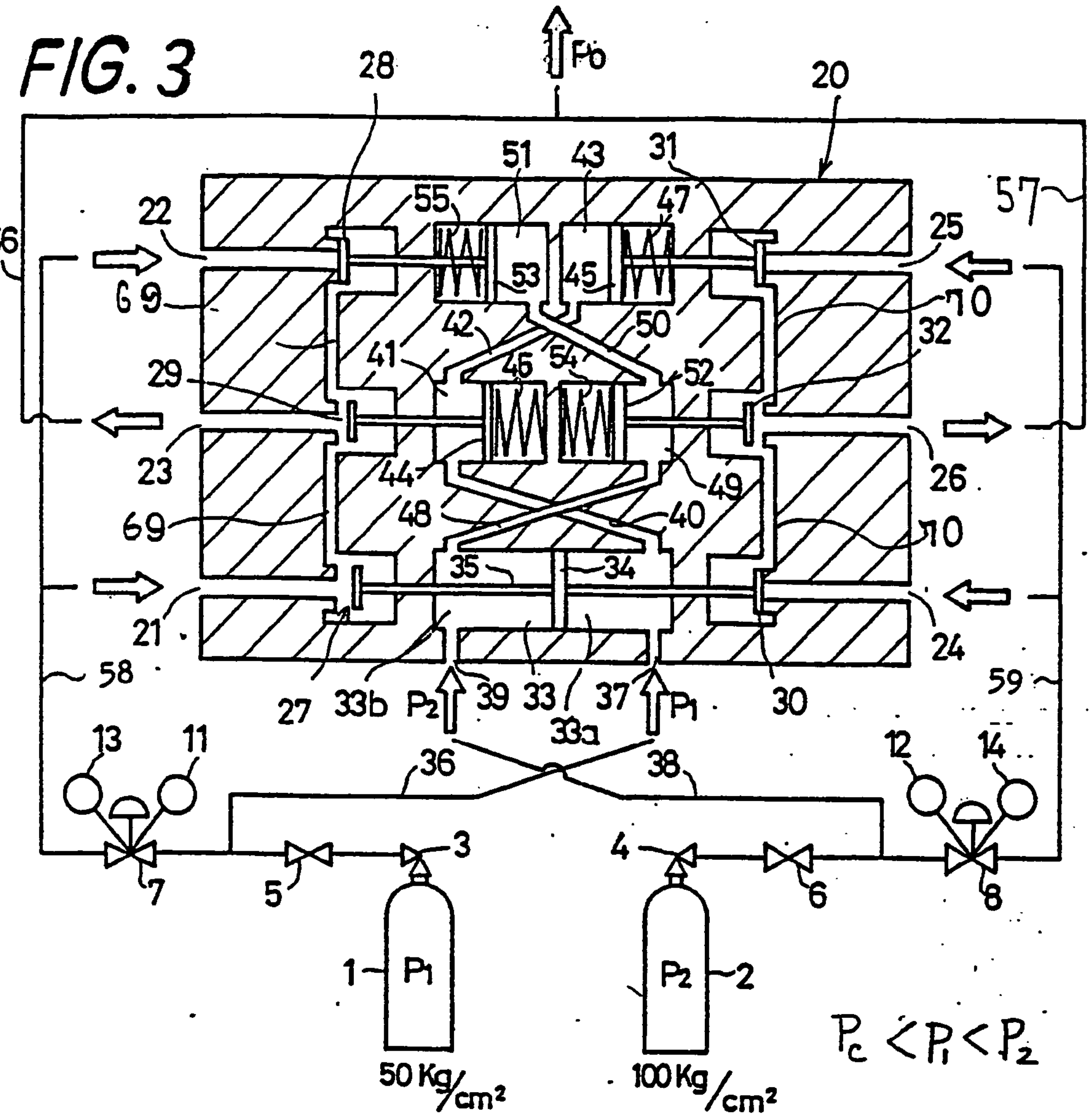


FIG. 3



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33b
P2
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33
37
P1
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33a
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P1
P2
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50 Kg/cm²
100 Kg/cm²
Pc < P1 < P2

FIG. 4

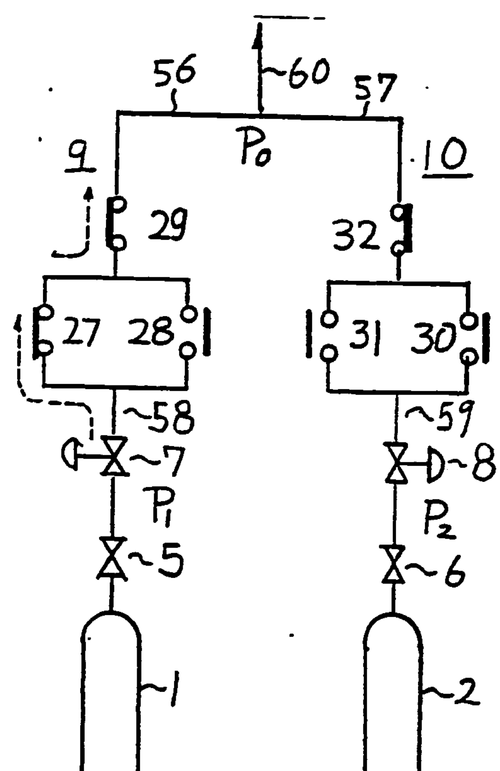

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FIG. 5

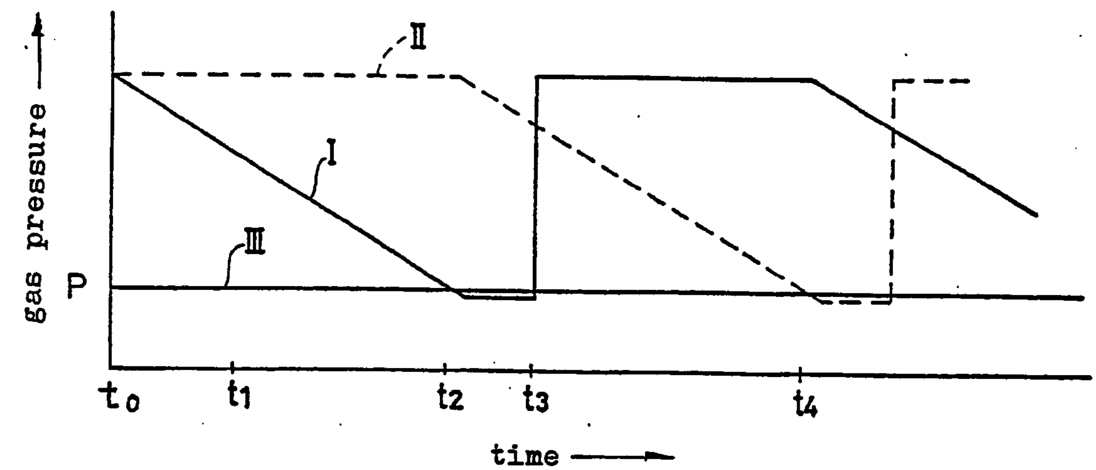


FIG. 6

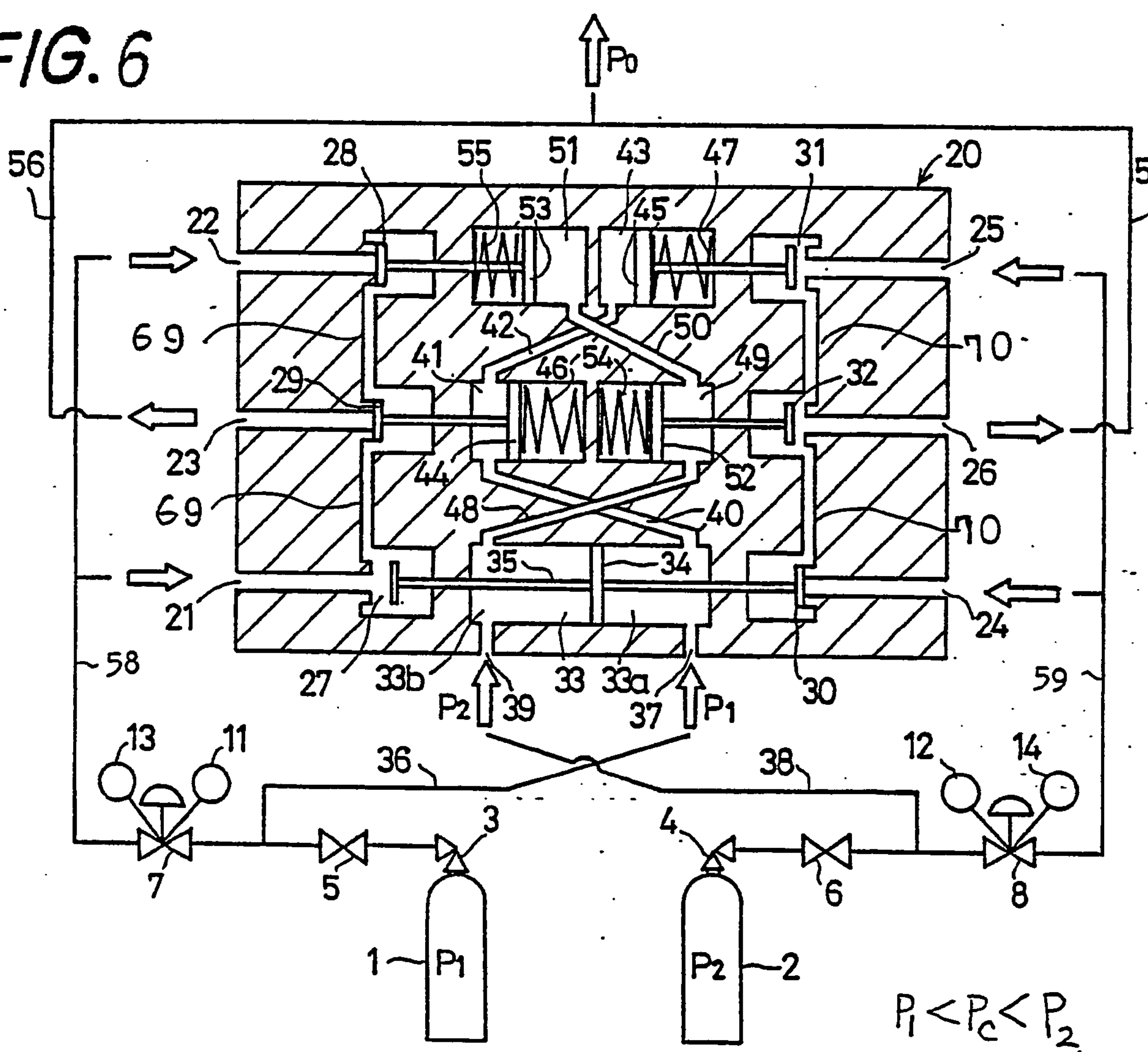


FIG. 7

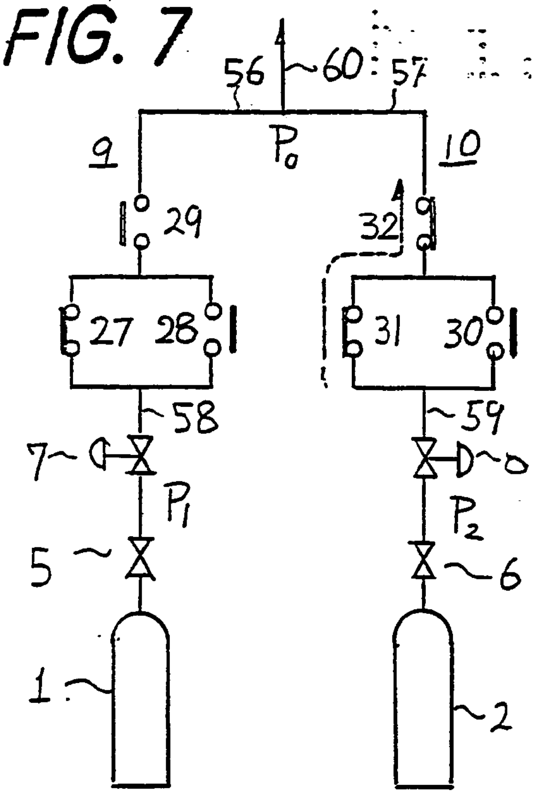


FIG. 9

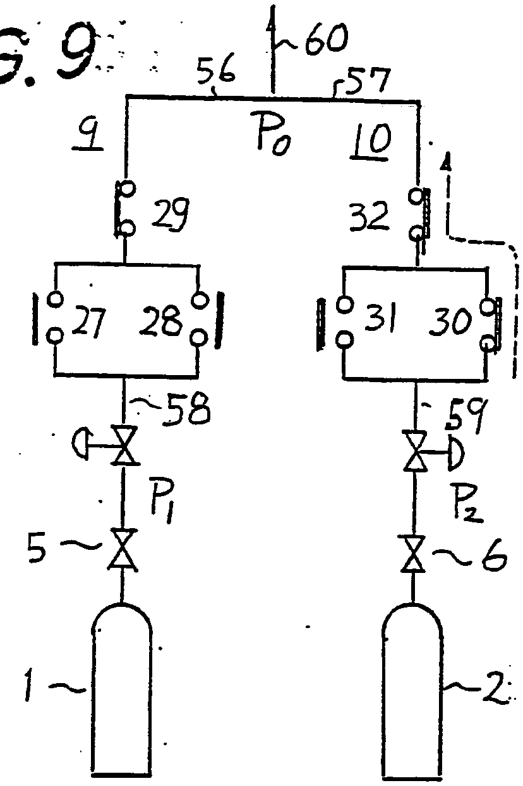
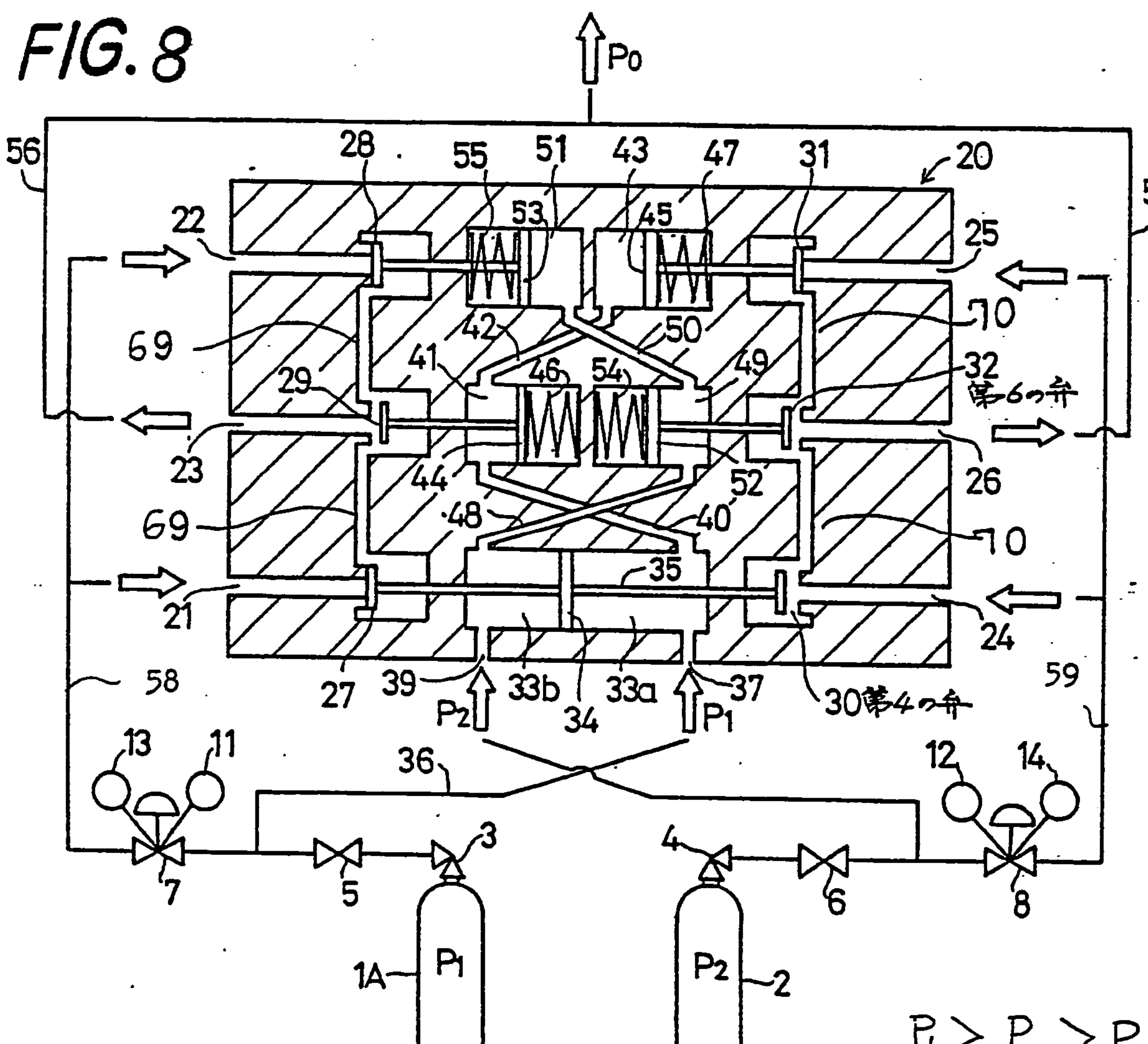


FIG. 8



$P_1 > P_2 > P_3$

FIG.10

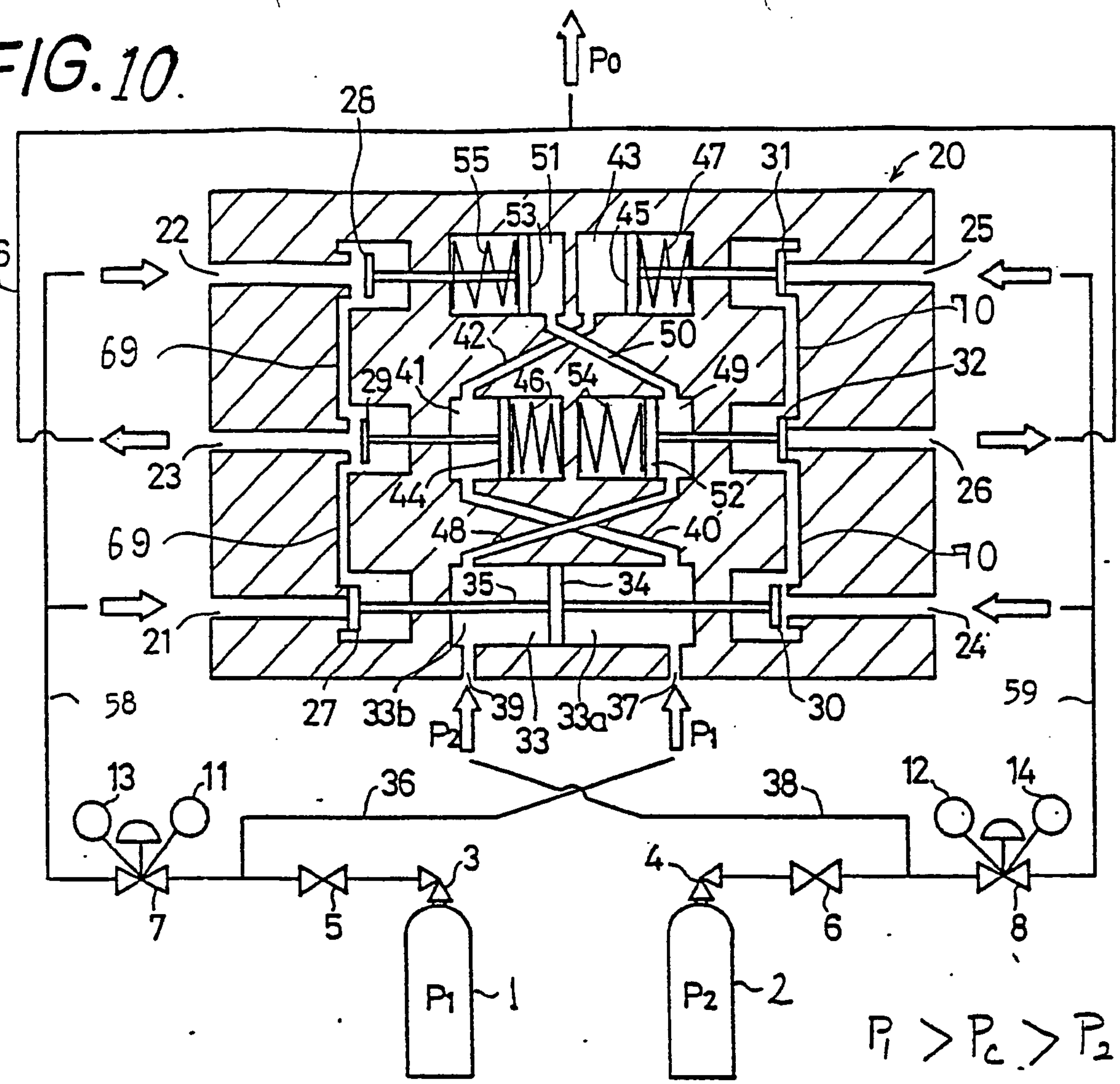


FIG.11

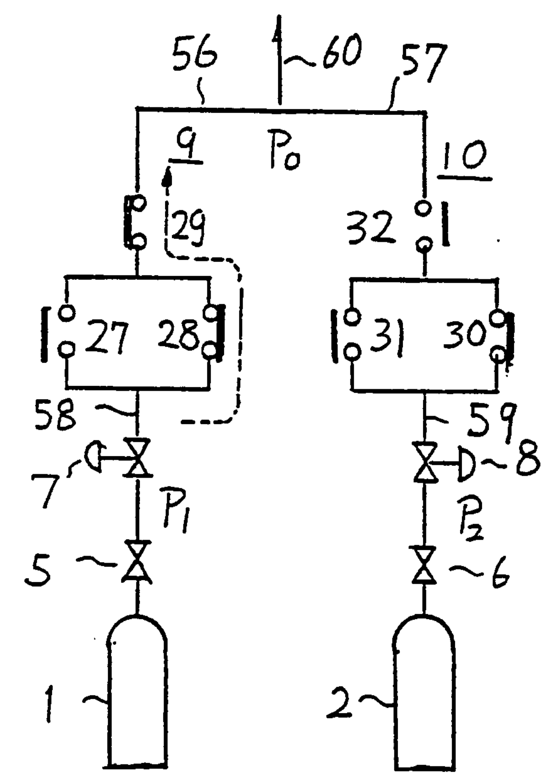


FIG. 12

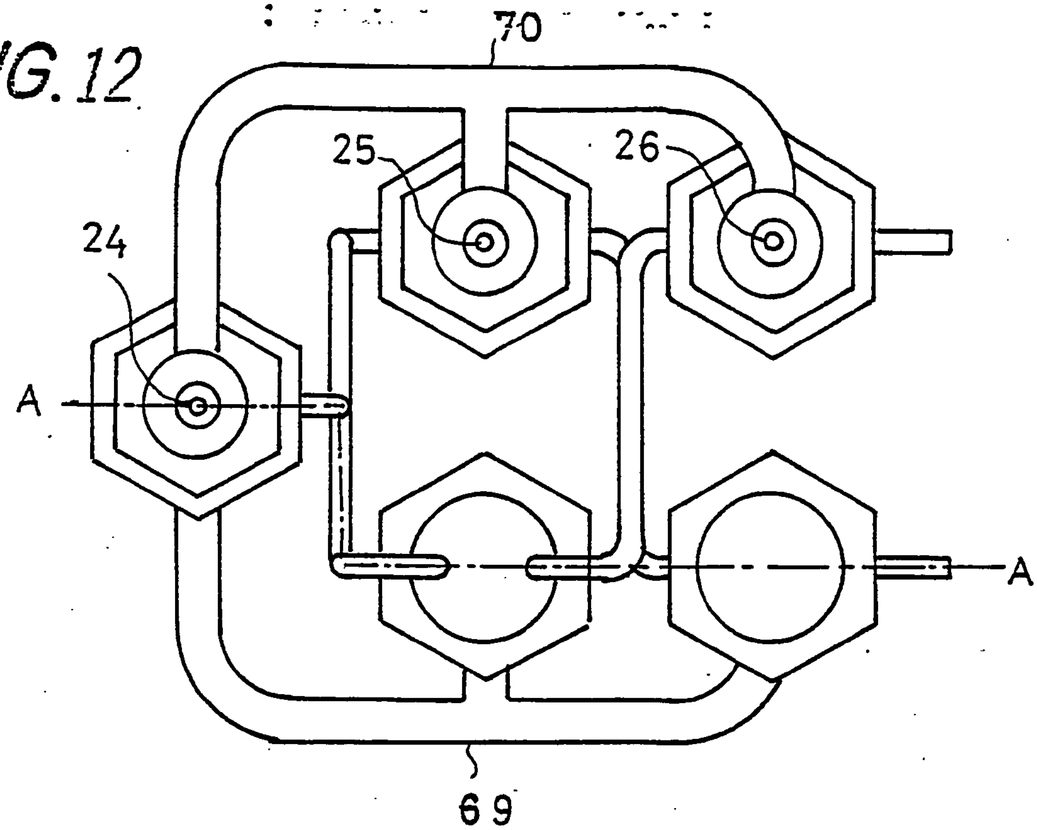

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FIG. 13

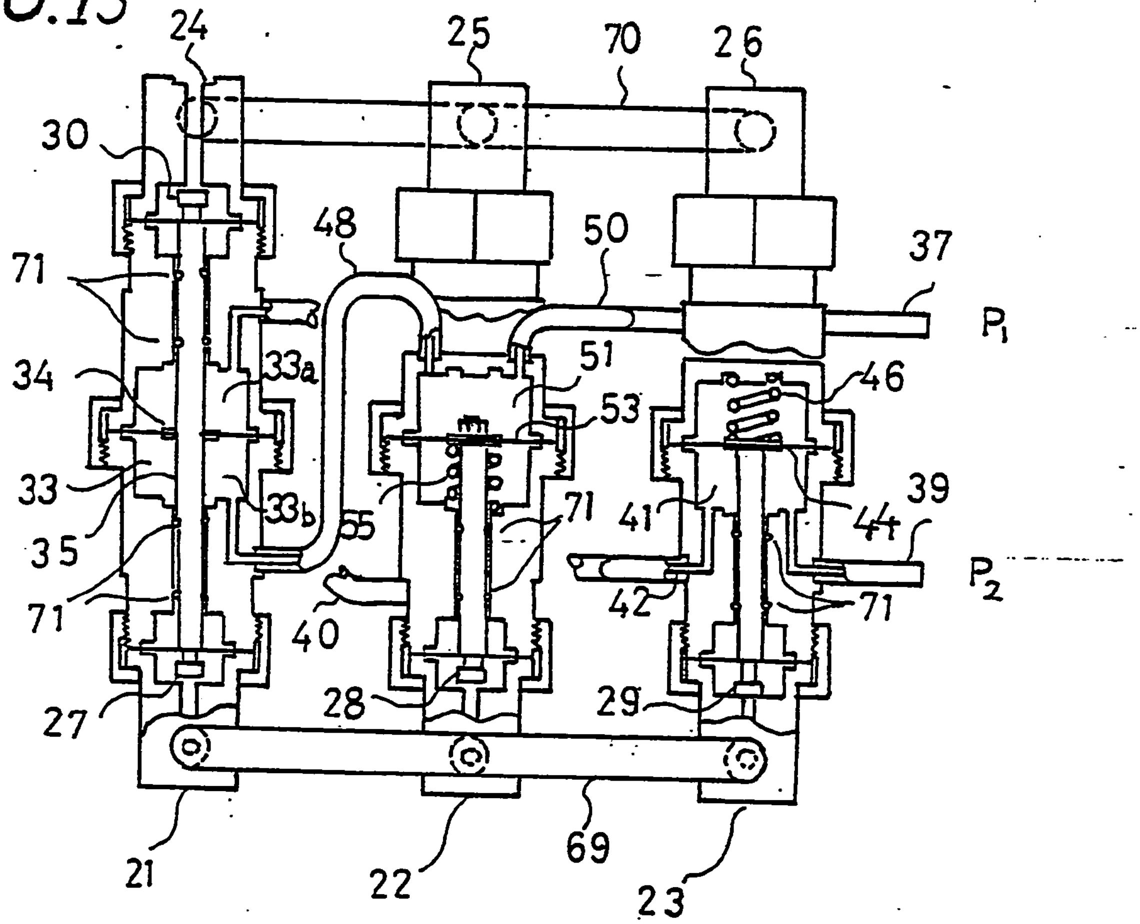
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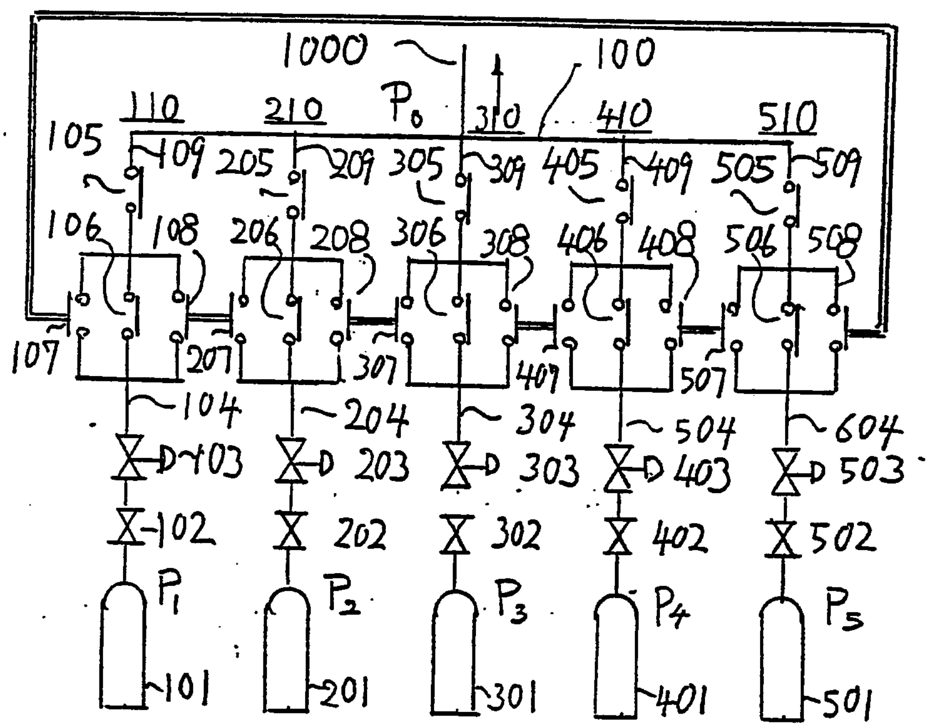
FIG. 14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P_3
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201
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(54) **Automatic gas distributing device, for supplying a pipe with gas from an alternative gas source, controlled by the direct application of high gas pressure of the source.**

(57) An automatic gas distributing device for delivering gas at a constant predetermined pressure from one of a plurality of high pressure vessels (1, 2) arranged in a ring connection. The device has flow paths (9, 10) corresponding to the high pressure vessels (1, 2), and is controlled by the direct application of the pressures of the gas contained in the associate vessels (1, 2) to the relevant stop valves (27-32). The device automatically set a high pressure vessel having a lower gas pressure than other vessels in operation, and interrupts the high pressure vessel in operation when the gas pressure of the vessel is reduced below a control pressure, and actuate the succeeding vessel.

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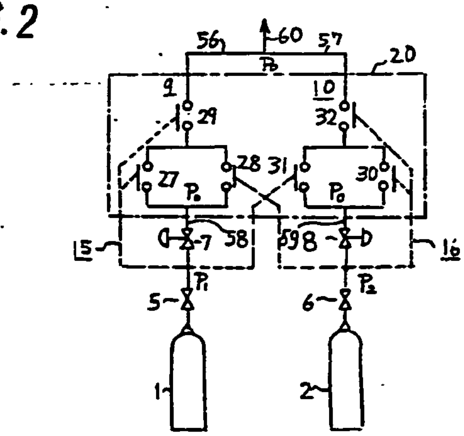
FIG. 2



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EUROPEAN SEARCH REPORT

Application Number

EP 87 11 0404

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	FR-A-1 490 561 (L'OXHYRIQUE FRANCAISE) * Page 1, left-hand column, lines 1-6; page 3, right-hand column, line 24 - page 4, right-hand column, line 24; figures 1-6 *	1,2	F 17 C 7/00 F 17 C 13/04
A	DE-B-1 257 176 (DRÄGERWERK, HEINR & BERNH. DRÄGER) * Column 2, lines 40-51; column 3, line 54 - column 6, line 13; figures 1,2 *	1,2	
A,D	US-A-4 597 406 (G. LOISEAU et al.) * Abstract; figures; column 2, line 7 - column 3, line 26 *	1,2	
A	US-A-2 768 640 (R.R. ZIMMER et al.) * Column 1, lines 15-18; column 1, line 64 - column 2, line 37; figures 1,2 *	1,2	
A	FR-A-2 456 273 (MESSER GRIESHEIM GmbH) * Page 1, lines 1-9; page 2, line 12 - page 5, line 27; figure *	1,2	

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

F 17 C
G 05 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	01-09-1988	VAN IDDEKINGE R.E.

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